



Application Significance and Prospect of High Thermal Conductive Insulation Materials in High Voltage Motors

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Abstract

With the development of economy, the quality and demand of power supply are becoming more and more strong. At the same time, China is actively developing new energy in the west, and needs to apply new transmission technology to long-distance transmission of power. The emergence of high conductivity insulation materials just conforms to the national demand, but there are still some problems with this material that cannot be overcome, and it still needs to make technical breakthroughs. The research and application of this technology is of great significance to ease China's energy shortage and achieve carbon neutrality.

Keywords

High thermal conductivity insulating material; High voltage motor; HVDC transmission technology

Introduction

Insulating materials refer to materials that can effectively isolate the inside of a conductor from air or other solid materials during processing, thereby achieving the purpose of electrical energy transmission, conversion and safety protection. With the continuous progress of society, China's commerce and industry have developed rapidly, and electricity consumption has also been rising steadily. As a result, high-voltage transmission technology has been widely used, and high-thermal conductivity insulating materials have become a research hotspot as new power equipment. At present, various large and medium-sized ultra-high temperature supercritical units that have been built and put into use in China use high flame retardant composite insulators. Although this type of equipment has advantages such as good dielectric loss characteristics and low power density, it also has certain temperature stability problems in actual operation, which limits the high thermal utilization of this type of high-voltage transmission equipment [2]. Therefore, it is necessary to increase research on this technology and equipment and carry out corresponding improvements, so that this technology can benefit thousands of households and alleviate the problems of energy shortage and uneven energy distribution in China.

1. Application of high thermal conductivity insulation materials in high voltage motors

With the rapid development of China's economy, higher requirements have been put forward for high-conductivity technology. High-voltage transmission line insulation materials also play an important role in the power field, and their application scope is becoming more and more extensive. First, giving full play to the role of materials can greatly improve the performance of equipment. The high-voltage direct current used to transmit electrical equipment, circuit

boards and other insulator surfaces generates thermal vaporization after ignition and combustion to generate cross-linking agents to achieve the purpose of increasing the voltage level; second, the application of some materials has a great impact on safety. When used as electrodes and liquid solutions or gases that must be used in industrial processes to discharge electrolytes, a flow guide cover is used to prevent the entire metal mesh from being destroyed and causing an explosion due to the local electric field. In high-voltage transmission lines, the conductivity of the electrolyte has an important influence on the surface of the insulator and the surrounding environment, which directly determines whether the high-voltage direct current grid is safe; in addition, related materials still need to be studied to improve the performance of the materials. Various insulating materials used in industrial production processes will also be subject to high-temperature thermal aging and mechanical damage [3]. Therefore, it is very necessary, urgent and effective to develop new high-efficiency, low-toxicity, corrosion-resistant and mass-produced equipment.

1.1 High thermal conductivity insulation material

High thermal conductivity insulation material refers to a new type of vibration isolation steel made of copper, aluminum and other metals and their oxides. It has low density, light weight, stable chemical properties, excellent damping characteristics, good weather resistance and corrosion resistance to meet people's demand for high-performance insulation products. In recent years, it has been widely studied and used in high-voltage motors and gradually applied to large-scale power equipment. High thermal conductivity insulation materials are used in large-scale equipment such as high-voltage motors and elevators. The performance of high thermal conductivity insulation materials will directly determine the safety and reliability of the entire system during operation. Therefore, it is necessary to conduct relevant technical research on it. At the same time, high thermal conductivity insulation materials have excellent comprehensive properties, excellent weather resistance, and sound insulation capacity of more than 20dB. Therefore, this new type of high-performance insulating plastic is a future development trend. At present, a new type of high-performance insulating plastic synthesized by molten salt solution type and ionic liquid polymerization method is used as a vibration isolation circuit to replace the traditional metal wire mesh with an electric furnace or other heat-conducting channel material to make a composite insulation layer, so as to improve the feasibility of high damping steel in large-scale equipment such as high-voltage motors and elevators, and further expand its application range.

1.2 Preparation process and reliability of high thermal conductivity insulation materials

The application reliability of high thermal conductivity insulation materials in HVDC transmission projects is reflected in the following aspects:

- (1) Improved reliability of power grid system operation. Since high thermal conductivity media have a small resistance, when the temperature rises, it will undergo drastic changes inside, and this effect is also very obvious in high temperature environments. By adopting insulation measures such as low dielectric constant, no contact with metal, and no radiation discharge phenomenon, it can effectively prevent external short-circuit faults and suppress voltage fluctuations and flashover interference;
- (2) Improved system insulation operation reliability. In HVDC transmission projects, since high thermal conductivity media have a large temperature coefficient, no contact with metal, and no radiation discharge phenomenon occurs, its internal electric field can achieve a very large strong coupling effect; and the characteristics of low dielectric constant, small resistance and shielding ability, the conductor manufacturing cost is extremely low, which can effectively reduce the overall cost of power equipment and improve the insulation operation reliability of the power grid system. The application of high thermal conductivity insulation materials in the reliability of power grid operation is of great significance and will further promote the development of high-voltage transmission technology in the power system towards efficient and safe power supply.

The preparation methods of high thermal conductivity insulating materials include immersion plating, melt deposition method and coating process. The most commonly used one is immersion plating. This method uses copper wire or zinc rod as raw material, melts it with iron tools, makes it contact with the base metal oxide, and then melts it at high temperature to form a current-resistant insulating plate; then uses the vacuum steam in the high-pressure heating furnace to produce slag splashing to cool and harden it, and obtains high thermal conductivity insulating materials, which can be directly used in the factory after drying. Secondly, there is the melt deposition method, which is one of the most commonly used methods for preparing high flame retardants. The melt deposition method is to compound the high thermal conductivity insulating material with the base metal oxide or graphite, so that their melting point is reduced from 50°C to 60°C, and then melt it at high temperature to form a current-resistant insulating plate, and then

use the furnace as a carrier to directly use auxiliary equipment such as high-voltage power supply and press to obtain high-conductivity polyethylene. In the preparation process of high thermal conductivity insulating materials, according to actual needs, different types, specifications and characteristics of melt deposition methods can be used for production.

1.3 Difficulties in applying high thermal conductivity insulation materials to high voltage motors

At present, the application technology of high-voltage insulation materials in China is mainly characterized by high conductivity, low energy consumption and low cost. However, it still faces many problems in actual production, such as:

- (1) Due to the low level of manufacturing technology of power equipment in China and the particularity of high-voltage transmission lines, the existing high thermal conductivity insulation materials have many weaknesses. For example, the tensile strength is insufficient or cracks are easily generated when the temperature is greatly affected. On the other hand, because high-voltage insulation materials are composed of a polymer compound with a metal matrix and are very unique, thermally conductive materials have a large energy absorption capacity at high temperatures, so it is difficult to be widely used.
- (2) Because high-voltage insulation materials are composed of a polymer matrix with paraffin as the main component, and then a series of processes such as sintering are used to obtain the product [1], the temperature characteristics are related to temperature, and the combustion performance also affects the safety of equipment operation and service life.

2. Application research of high thermal conductivity insulation materials

The application of high-conductivity insulating materials mainly includes the following application research:

- (1) Under high-voltage direct current and supercritical temperature, it has good thermal stability, high temperature resistance and good electrical insulation. At present, it is very common and effective to use high-conductivity polyethylene as a protective core material for power equipment in China.
- (2) Under high-voltage alternating current or supercritical temperature conditions, it has good insulation performance and its resistivity is relatively high.
- (3) Under high-voltage direct current conditions, it can effectively prevent or reduce leakage and flashover.
- (4) High-damping, pollution-free gas-type composite dielectric polymers are widely used as new high-performance insulating polymer materials. In addition, inorganic ceramic cellulose is used as a reinforcing filler to fill the flexible matrix to improve insulation performance, etc. [5].

2.1 Scope of application

The application scope of high-voltage insulating plastics is mainly in the following aspects: First, in the power industry, in order to improve the power grid's ability to resist sudden high-conductivity current transmission, high-resistance insulators must be used. The principle is to increase the voltage by applying pre-tension to the high-voltage conductor. This method has certain advantages, such as lower temperature, relatively stable and larger impact breakdown field, so it can be used to replace other methods in some special cases to improve voltage stability and current conductivity; but it may reduce system impedance, thereby increasing equipment costs and affecting safe operation. Secondly, in the field of power industry. Because the pre-tension of high-voltage conductors is large and there are harmful substances such as thermal radiation, flammable gases and dust that can cause damage to equipment or cause fire accidents, in order to avoid such problems, high-conductivity insulators must be used instead of traditional steel wire ropes as a protective layer, thereby greatly reducing their danger. Finally, the communications industry: Since high-voltage cables have a long length and a wide transmission distance, cables can be used instead of metal insulators.

2.2 Optimization of high thermal conductivity insulation materials

At present, the optimization of high thermal conductivity insulation materials is mainly aimed at high-voltage direct current transmission technology, and its application field is relatively wide. Most of the power equipment used in the high-voltage alternating current power supply network, such as generators and transformers, adopt high current conduction devices. For these power generation systems, the voltage level must be improved. With the continuous development of my country's economy, the construction of power grids and the continuous improvement of related

scientific and technological levels, the application scope of high thermal conductivity insulation materials has been continuously expanded, which is mainly reflected in the following aspects:

- (1) Improving the operating voltage level of high-voltage lines in power systems. In the actual engineering operation process, in order to reduce the loss of power equipment and improve the economy, multiple generators are used to jointly provide high-quality AC power for the power grid; for high thermal conductivity insulation materials, through technical upgrades, it can better meet the requirements of different AC loads and higher performance indicators.
- (2) Improving the operating voltage level of the power supply network and improving the insulation performance of the transmission line. In the high-voltage direct current transmission line system, the economic efficiency is improved by reducing the loss of power cables.
- (3) Improving the transmission capacity of the power supply network. The application of high thermal conductivity insulation materials can not only meet the relevant requirements, but also reduce the loss during power transmission and improve its economy.
- (4) Improving the reliability of the power supply grid [2].

2.3 Characteristics of high thermal conductivity insulation materials

High thermal conductivity insulation materials have the following characteristics, such as the insulating oil temperature is smaller than the heat flux density, the temperature distribution is uniform and does not produce large-scale fluctuations, which is conducive to improving system stability and reducing motor losses, thereby effectively improving the quality of electric energy. This is the main advantage of high thermal conductivity insulation materials. Secondly, high thermal conductivity and voltage are relatively stable and lossless under high temperature conditions, and the requirements for long equipment life are not high. At the same time, it also has excellent performance and low loss. These characteristics make the application range of high thermal conductivity insulation materials very wide. Now China has taken high thermal conductivity as one of the main energy sources in the high-voltage direct current transmission system, and has carried out research, development and development work on it, providing a possible direction for the future development of new technologies [2].

3. Prospects for the application of high thermal conductivity insulation materials in high voltage motors

With the rapid development of my country's national economy, high-conductivity media play an increasingly important role in the fields of electricity, railways, etc., which has higher requirements for high-conductivity media. The application areas of high thermal conductivity insulation materials are mainly concentrated in high-voltage transmission and frequency converters, high-voltage technology and high-performance electrodes, and most of them use existing high thermal conductivity insulation materials. For new materials, such as high thermal conductivity polyoxyethylene composite materials, there are few studies. With the rapid development of my country's power industry, many domestic research institutes and enterprises pay more and more attention to this type of new insulation technology, so this type of research and development and production will become a trend in the next few years. So far, high thermal conductivity insulation materials have been widely used in the electrical field due to their excellent comprehensive mechanical properties. The main reason is that they have excellent flame retardant properties and can be used as a new high-performance insulation product to replace traditional materials such as traditional inks and metal salts. However, due to a series of defects in this type of polyoxyethylene composite system, it is difficult to achieve a breakthrough in this type of technology. Therefore, in the next few years, as the conductivity density of high thermal conductivity polymers continues to increase, the requirements for the surface performance of high-voltage inverters become more and more stringent, and environmental pollution becomes increasingly serious, all of these will lead to the acceleration of research and application of high thermal conductivity insulation materials, which will become one of the important directions of future research and development [1].

3.1 Application and service life of high thermal conductivity insulation materials in high voltage electricity

The application of high thermal conductivity insulating materials in high voltage electrical engineering mainly includes the following aspects:

- (1) Low temperature super condenser. It is a new type of high-efficiency heat exchanger with a certain temperature range formed by the co-crystallization of ceramic melt, copper wire or metal oxide and high temperature organic.
- (2) Circulation furnace mainly plays a cooling role in high voltage electrical engineering. The main function of the circulation furnace is to convert the insulating material in the high temperature medium into flammable and explosive properties, thereby improving the thermal efficiency of the equipment.
- (3) High voltage arc discharge device has obvious advantages over other conventional non-destructive testing methods: it can avoid local overheating caused by long-term exposure to low voltage, and can be transmitted over long distances, effectively reducing power consumption and environmental pollution.
- (4) High permeability magnetic materials are mainly used in circulation furnaces for non-destructive testing and ultra-high voltage isolation, thereby extending the service life of the equipment [4].

3.2 Service life of high thermal conductivity insulation materials in high voltage electricity

During high-voltage power transmission, high-thermal-conductivity insulating materials generate a large amount of heat due to the increase in temperature and the force between electric fields. This heat can be discharged through cooling circuits, condensers, etc. However, when it is at low or high temperatures, it will cause damage to the equipment. Therefore, it is necessary to consider how to extend its service life, improve its ability to resist contamination, and reduce the occurrence of overvoltage. In addition, low-temperature super condensers, circulating furnaces, and molten salt coolants can be used to control the temperature and greatly improve its conductivity, thereby reducing the economic losses caused by the damage to the equipment due to the resistance of the insulating material [3].

4. Conclusion

This paper mainly studies the modern application and future development prospects of high thermal conductivity insulation materials. It is known that due to the characteristics of high specific energy density and low density, high thermal conductivity insulation materials can make up for the defects caused by the performance differences of traditional metal matrices and polymer composite materials as a special new type of high-performance filler. With the continuous improvement of scientific and technological levels and people's increasingly stringent requirements on its performance, high-voltage direct current transmission technology will inevitably become the mainstream trend in the future development process, and for high thermal conductivity insulation materials, its application prospects are broad. Insulation materials are the most widely used high-conductivity insulation equipment in today's society. They play an important role in the power system. At the same time, this technology has high economic benefits and can be widely used in the power system, thereby achieving the purpose of energy conservation and emission reduction.

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